NET-CENTRIC C2 IN NEAR AND FAR SPACE

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ABSTRACT

The Virtual Mission Operations Center (VMOC) was an Office of the Secretary of Defense Rapid Acquisition Incentive Net Centricity (RAI-NC) Initiative executed as a collaborative experiment between the Air Force Space Battlelab, Army Space and Missile Defense Command Battle Lab (SMDBL), and NASA's Glenn Research Center (GRC). During June 2004, the VMOC team hosted an operational demonstration at Vandenberg AFB, CA, under advocacy from the 14th AF commander. The on-orbit space asset is owned by Surrey University, England, and is part of the Disaster Monitoring Constellation (UK-DMC1), operated by Surrey Space Technology Ltd.

1. INTRODUCTION

Net-centric information processes are pivotal for the Transformation process forward to the Future Force. As part of the science and technology supporting this effort, Advanced Concept Technology Demonstrations (ACTDs) and experimentation efforts are proving grounds for concept development. Via the VMOC baselined architecture, planning moves forward to incorporate this knowledge and technology to other platforms and mobile ground station requirements.

Integral to this experiment was a Cisco mini router incorporated into the UK-DMC1 build, to demonstrate Internet Protocol (IP) C2. Thus, besides being a Joint effort, the VMOC experiment included academic and international organizations.

1.1 IP Directly Supports the Warfighter

The VMOC experiment used IP to acquire satellite data, dynamically task a satellite payload, and perform TT&C of on-orbit satellite assets. The experiment furthermore demonstrated the flexibility of IP, as it can be used wherever an Internet connection is available (LAN / WAN, uplink). This was accomplished via remote field operations set up at Vandenberg AFB with Army Space Support Element (SSE) "Toolset" personnel and USAF personnel. The SSE toolset is a suite of hardware and software successfully demonstrated during overseas operations in a deployed setting to provide space information to the theater of operations.

Operations with IP demonstrated secure, prioritized, permission-controlled, information acquisition, and subsequent dissemination. VMOC successfully demonstrated the ability to use IP for standardization of telemetry, tracking, control, and communications elements, and interoperability between terrestrial (land, sea, and air) and satellite-based systems, quantifiable with metrics data obtained throughout the experiment .

1.2 Experiment Overview and Specific Net-Centric Objectives

The stated problem for this experiment was: Theater commanders need a real-time solution for maximizing space operations to include retrieving satellite health data, sensor data, and tasking of on-orbit satellites.

The solution: The VMOC hardware and software enables the Warfighter to access, task, and retrieve data from satellites via the Internet. The final metrics analysis and concurrent testing indicated the VMOC experiment met its objectives in proving IP allows quick and simple field operations under a variety of circumstances.

The demonstration overview can be condensed into three main thrusts:

1. Demonstrate multiple field users, with various missions, acquiring sensor data and performing TT&C of the Surrey Microsat
2. Connect to the Surrey Microsat through a NASA ground antenna
3. Demonstrate storage and handling of data using a Knowledge Management Database

The use of Internet protocols allowed specific Net-centric C2 capabilities to be demonstrated:

1. TT&C of satellites
2. Payload tasking
3. Warfighter access to databases

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4. Warfighter C2 of on-orbit sensor platforms

Specific tasks and user performance were elements essential to data collection and metrics analysis - All demonstration objectives were met. History was made on 9 June 2004, when through the Internet, the first-ever mobile IP C2 of an on-orbit asset.

2. THE VMOC ARCHITECTURE

The VMOC distributed architecture has paved the way for high survivability and rapid re-configuration capability for an interoperable, secure, Internet resource. It is integral to the net-centric concept for the Future Force. This is needed in the battlefield environment now, and in the direct future. This research is applicable to the Warfighter in countless scenario descriptions, forward-deployed or in sanctuary, quick and secure, mobile communications. It is furthermore applicable for platform and sensor C2, as well as interoperability for autonomous space and near space platform operations.

3. OPERATIONS

During the first week of June 2004, the experiment included demonstration of ground station flexibility by using a non-UK ground station, handling and storage of NASA Knowledge Management capabilities, and testing of the secure architecture (7 layers of security and encryption), via the AF Information Warfare Center (AFIWC). As the demonstration week progressed, deliberate intrusion attempts were monitored however, none proved to be successful in burrowing into the secure Internet tunnel.

The Army's SSE personnel set up a field Tactical Operations Center (TOC) at Vandenberg AFB, with Internet connectivity through a commercial satellite provider. The SSE mobile ground system (mounted on a M1113 HMMWV) provides global, IP-based, "reach-back" broadband communications supporting forward deployed soldiers. The SSE provides space services (i. e. analysis, estimate, IPB) and products (i. e. commercial imagery) to operating commanders. For the purposes of this demonstration, there were no LAN/WAN TT&C connections in place, the SSE was 100% dependant upon the VMOC for TT&C.

As the scenarios were executed deliberate fail-overs between servers at NASA GRC, and AF Center for Engineering Research (CERES) Colorado Springs were induced to force testing of the system architecture design for seamless, uninterrupted operations. This deliberate action proved the robustness of the VMOC architecture, paving the way for further information hand-over experimentation and evaluation. This robustness was evident due to the fact that operations continued during satellite passes, with deliberate fail-overs induced at those times. This also proved the elimination of a single point of failure without duplicating the mission control center.

3.1 Experiment Taskings

The following list includes the tasks done by trained and untrained operators at the Army SSE field location. A trained operator was defined as a person who received training time on the VMOC software. An untrained person was just that, a person who sat down at the console and performed operations without prior knowledge of the system. Metrics were collected on both types of operators.

The tasks performed were:

1. Demonstrating secure operations over the open Internet,
2. Monitor active intrusion attempts,
3. Validate multiple users, and perform contention control,
4. Obtaining real time data from the Surrey UK-DMC1,
5. Obtaining real time data from a satellite math model,
6. Scheduling access time to spacecraft during orbital passes,
7. Identification of the appropriate ground station for TT&C / C2,
8. Communications with NASA GRC VMOC to provide shadow operations, and
9. Demonstration of the Primary to Shadow failure between VMOCs, with no impact to operations.

The four critical items that were met by the experiment were:

C-1: Does VMOC provide access to payload information for the Warfighter?

C-2: Can the field users request information from a platform or sensor?

C-3: Can field users request information from existing databases?

C-4: Are Internet protocols suitable for operations?

The four critical items above were further augmented by measures of effectiveness and measures of performance (MOEs and MOPs). Each task had multiple MOEs and MOPs. For example, for the task TT&C1, there were six such measures. At the end of specific tasks, the operators filled out a survey. These surveys were subsequently tabulated. Data indicated a variety of desired information, ranging from usability and ease of operator- to-software interfacing, to prioritization and secure commanding utilization.

TASK:	Operator Tasks	Performance time:	X-Walk Ref.:
You have been asked by the vehicle engineer to take a state of health for the Surrey UK DMC satellite and record the battery voltage. Determine the next available pass time and request telemetry for that pass.	1. Log on to VMOC 2. Determine mission priority 3. Request pass times and data 4. Receive feedback from VMOC 5. Determine pass times 6. Request telemetry for selected times 7. Record battery temp when recieved	2 min	MOE 1-1 MOE 1-2 MOE 2-1 MOP 2-1-2 MOE 2-2 MOE 4-1

3.2 Experiment Evaluation

The task scenarios were designed for exercising the VMOC system in real time, evaluating system and user performance, and noting where improvements can be made to this baselined design. Both the Army SMDBL and AF CERES have expertise in testing and evaluating C2 systems. Observations, analysis, and evaluation of VMOC functionality were presented to each Joint Command element, and to RAI-NC by an end report. NASA GRC's on-going work with orbital IP networking used this experiment in a similar manner.

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CONCLUSION

By combining the dual military and NASA air and space core competencies, the groundwork was set for IP use and desktop browsers. The VMOC proved this interoperable concept from a fielded laptop. It was a victorious C2 demonstration for space and near space platforms, sensor payloads, and manned and unmanned aerial vehicles.

The general consensus that all objectives were met and the experiment was a success in demonstrating the use of mobile IP for on-orbit TT&C and C2. Likewise, the operator tasks and software interface demonstrated usability and flexibility within the architecture. And finally, using this architecture over the Internet with world-wide accessibility, furthermore demonstrated the architecture was secure from deliberate intrusion attempts. The baselined VMOC architecture therefore, lays the foundation for robust IP applications designed to facilitate Warfighter information communications, in all situations.